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If primordial black-holes exist, what would be the gravitational wave background noise they would produce for LISA, DECIGO, and BBO?

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According to the standard model primordial black holes (PBHs) could have been generated during the first few moments after the big bang as consequence of density fluctuations of matter. Although most regions of high density would be quickly dispersed by the expansion of the universe, PBHs would be stable, persisting to the present.

If this really happened, LISA, DECIGO, and BBO might detect the gravitational wave background produced by those PBHs.

Depending of what PBH population exists in our galaxy the gravitational wave background produced by them might give trouble for these space interferometers in their task to detect other signals.

We calculated the PBH background noise in two different ways:

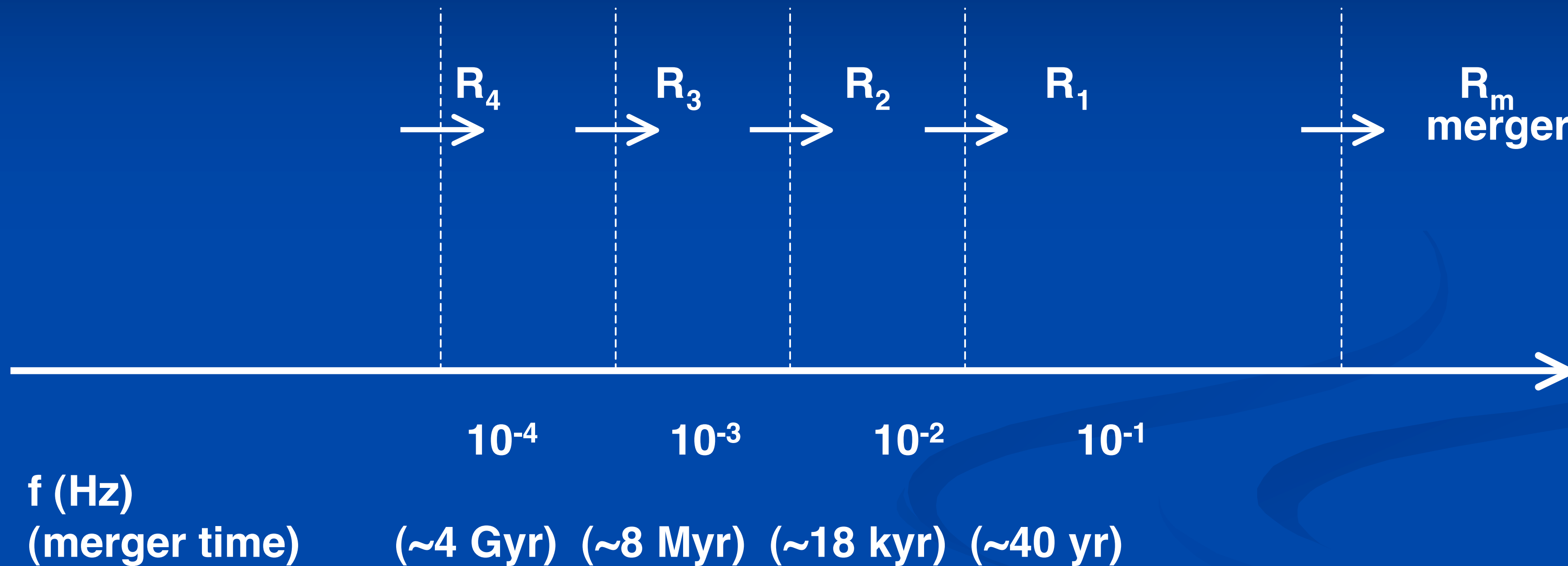
1) Starting from the distribution function proposed by Nakamura et al. (1997) for the PBH binaries created in the Universe, and evolving that distribution function to the present;

2) Assuming a steady state regime for the distribution of PBH binaries emitting GWs above 10^{-4} Hz.

In both cases we assumed circular orbits, the merger time given by Peters and Mathews (1963) and Peters (1964), the GW amplitude signal for a binary system given by Thorne (1987), all PBHs with 0.5 solar mass, and a Milky Way halo distribution for the PBHs with Earth 8.5 kpc away from the halo center.

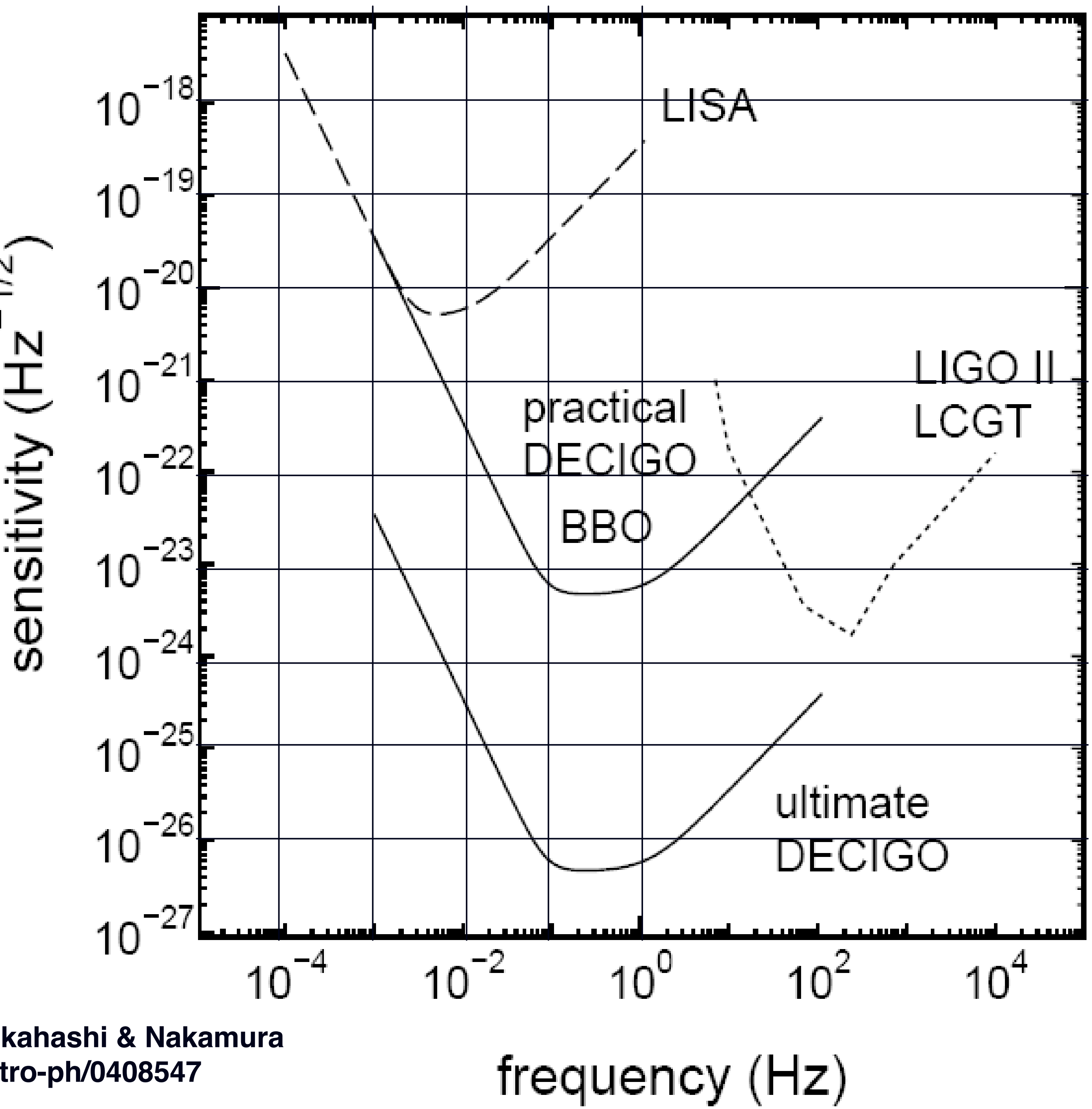
The results of the two methods were off by only 20-40%.

What we mean by steady state regime for the PBH binaries?



$R_m = R_1 = R_2 = R_3 = R_4$

f = 0.030 mHz ◊ ~2 Tyr (merger time)
f = 0.056 mHz ◊ 17.7 Gyr (merger time)
f = 0.062 mHz ◊ 13.7 Gyr (merger time)



Merger rate in the galaxy

1 x 10^{-2} /year

1 x 10^{-5} /year

1 x 10^{-8} /year

1 x 10^{-11} /year

1 x 10^{-14} /year

Time of observatio

2 years

1 month

1 second

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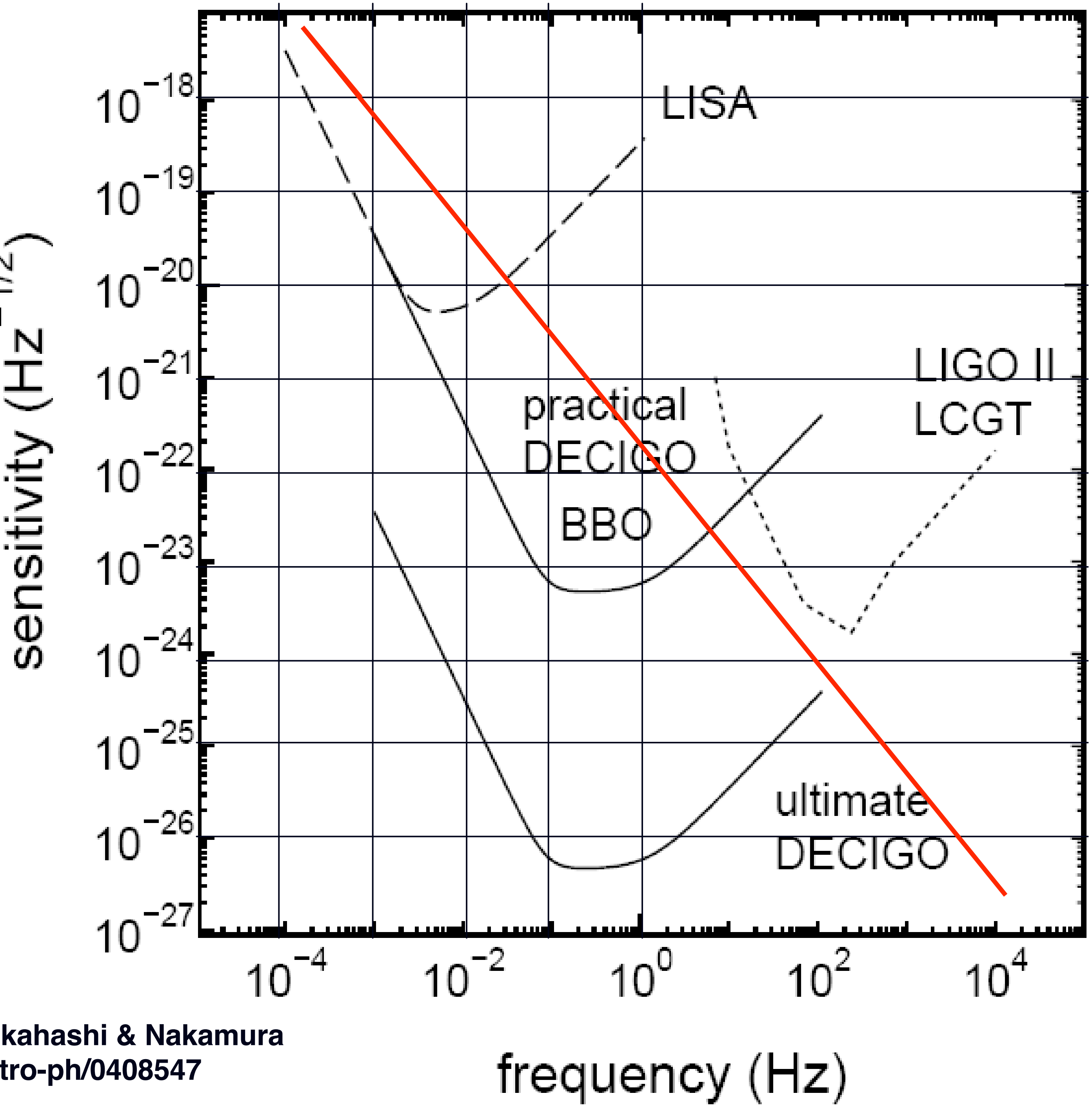

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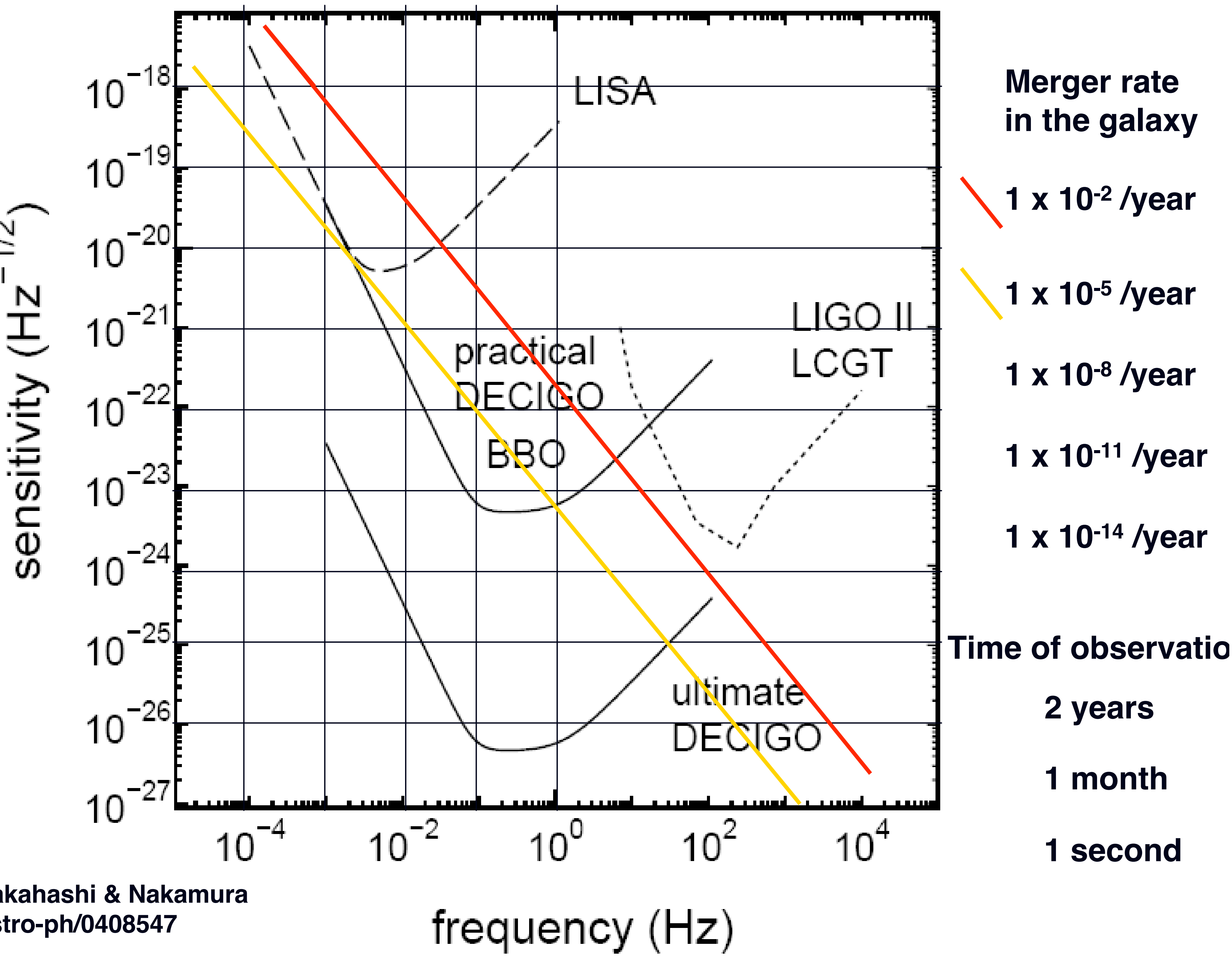

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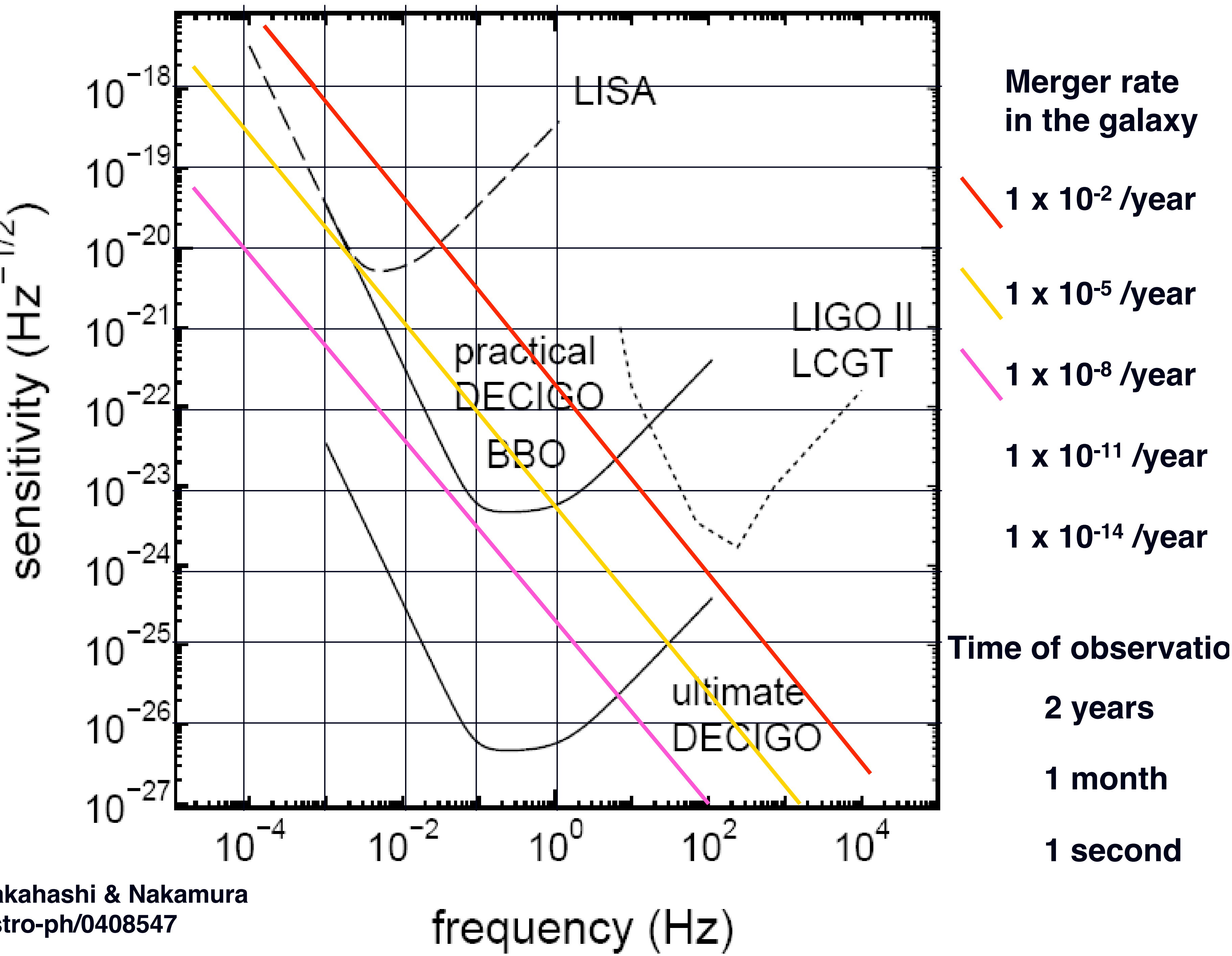

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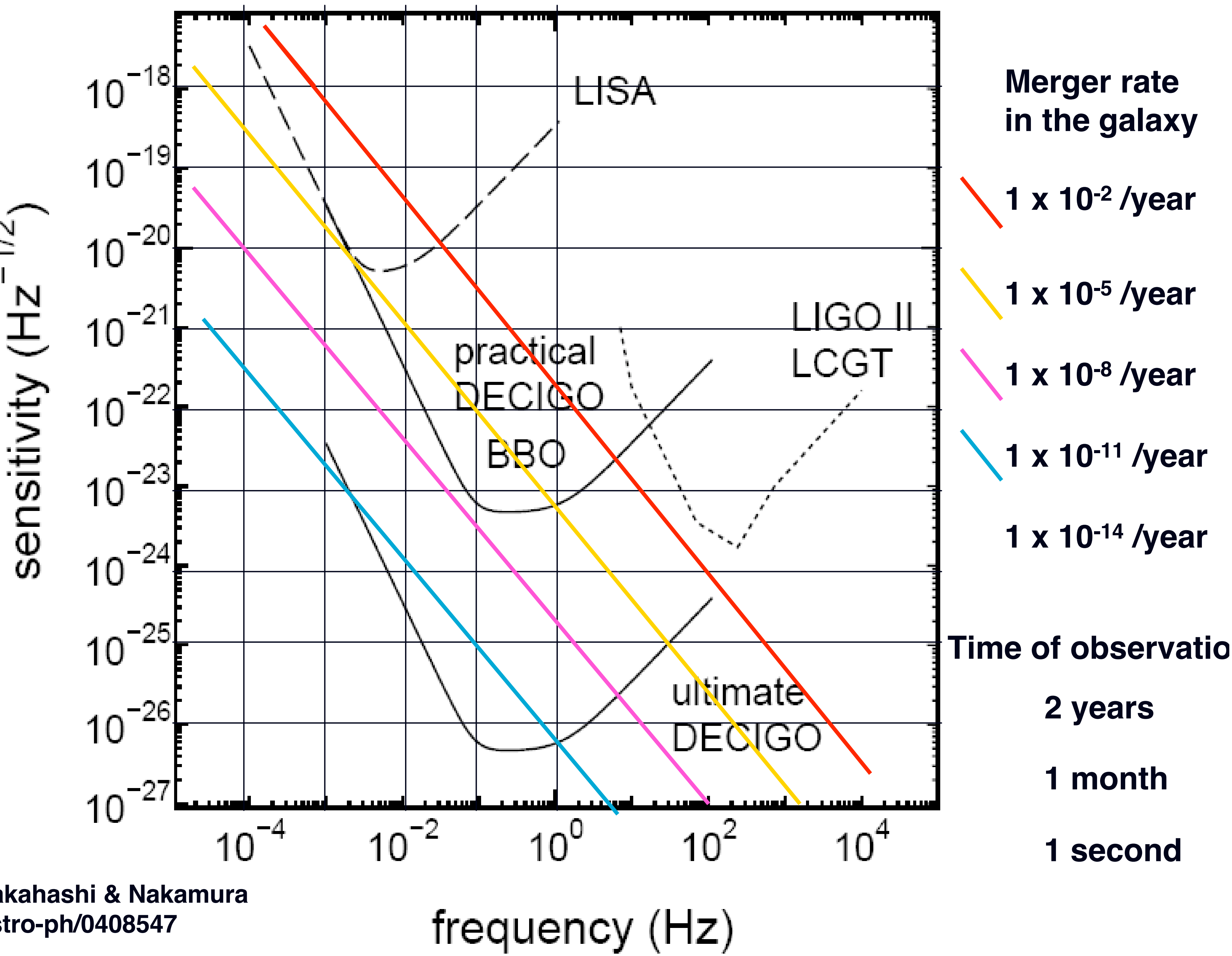

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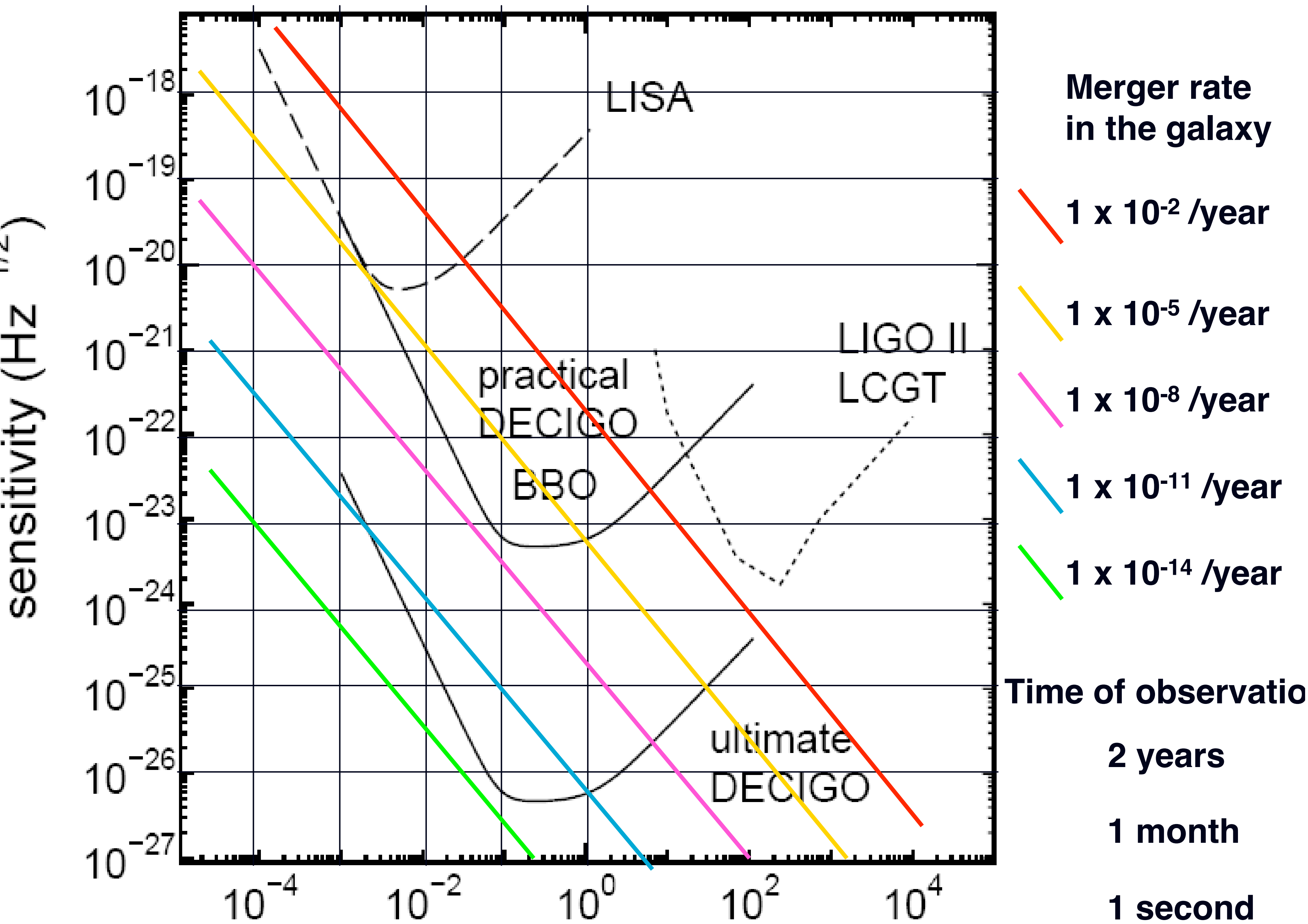

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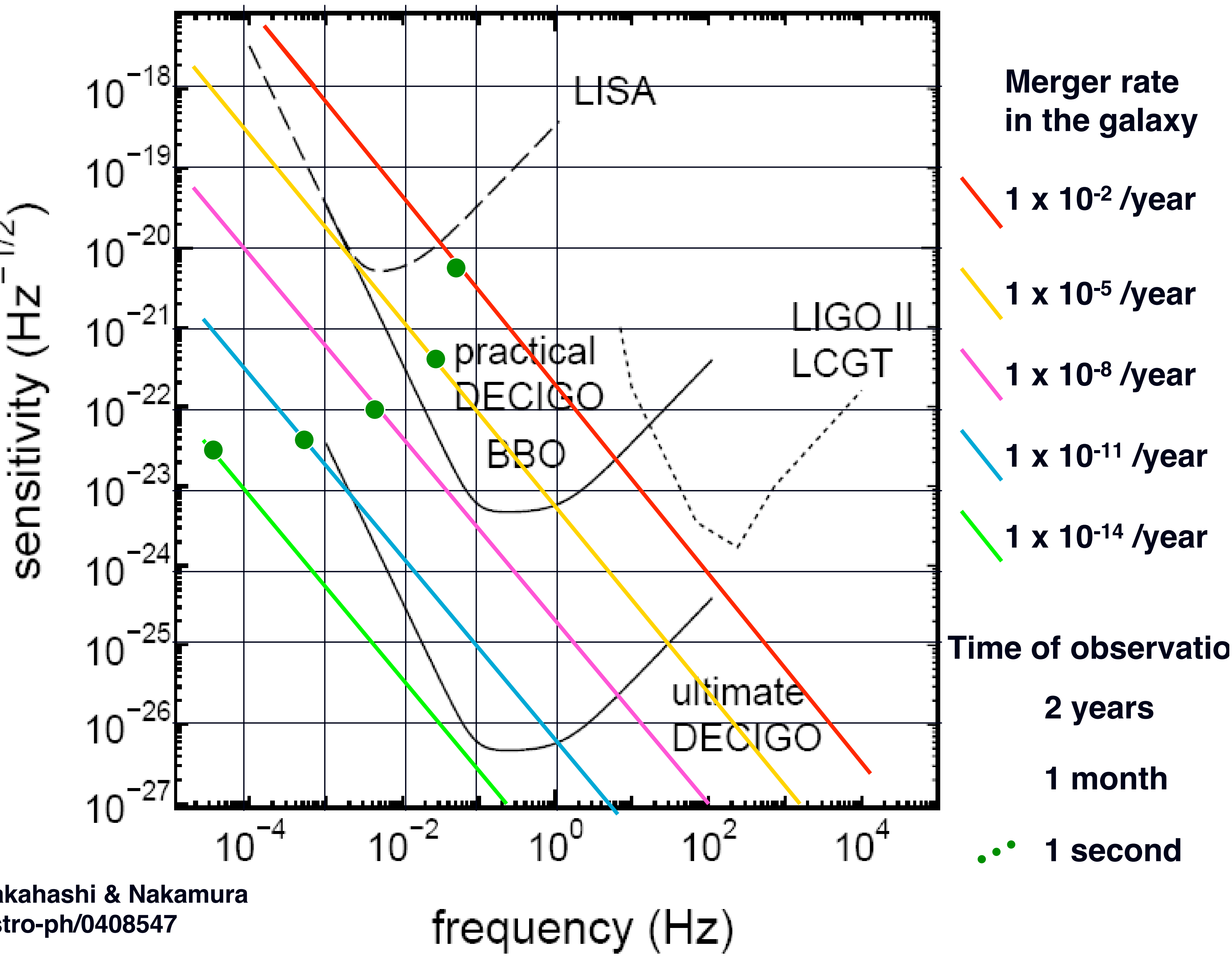

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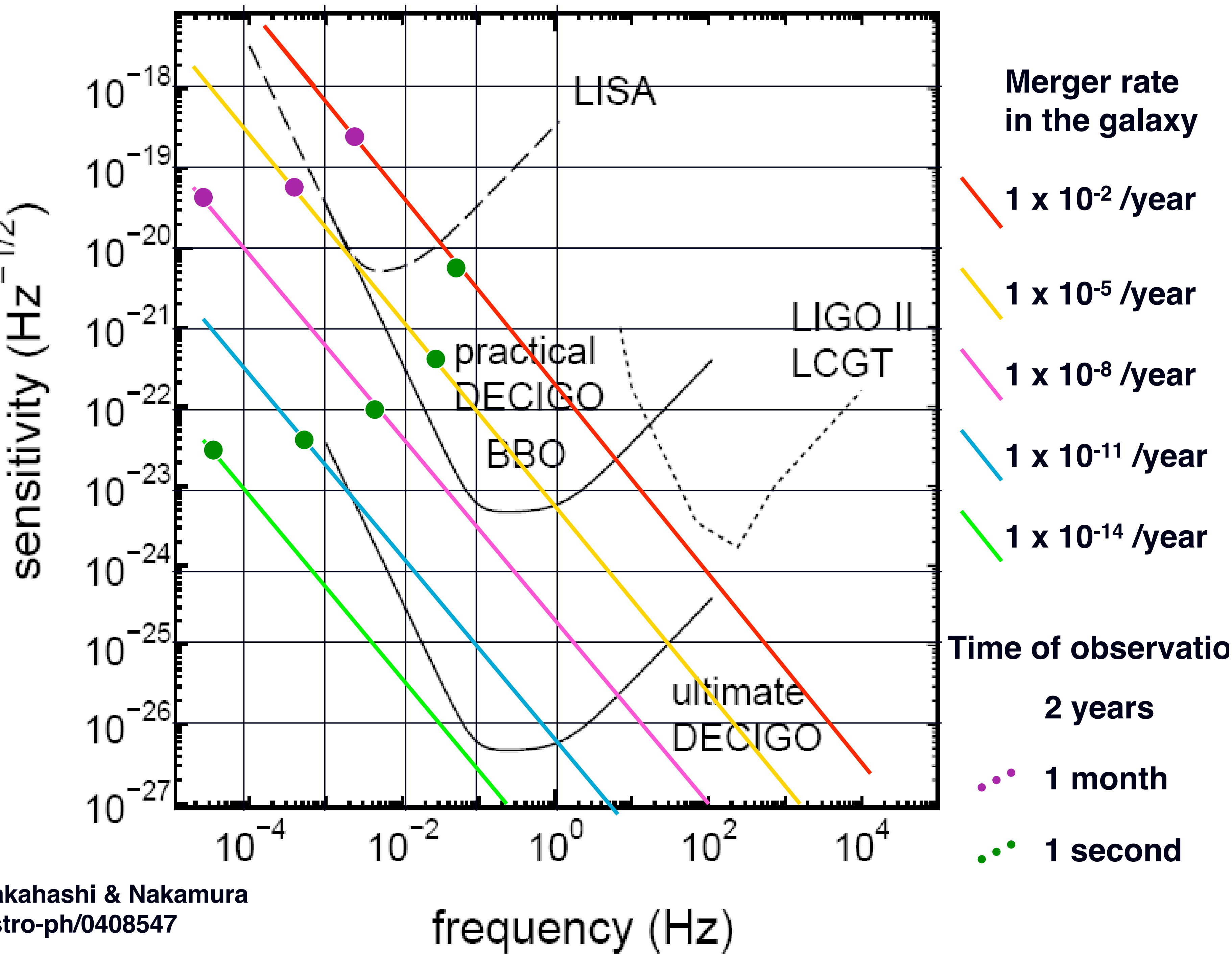

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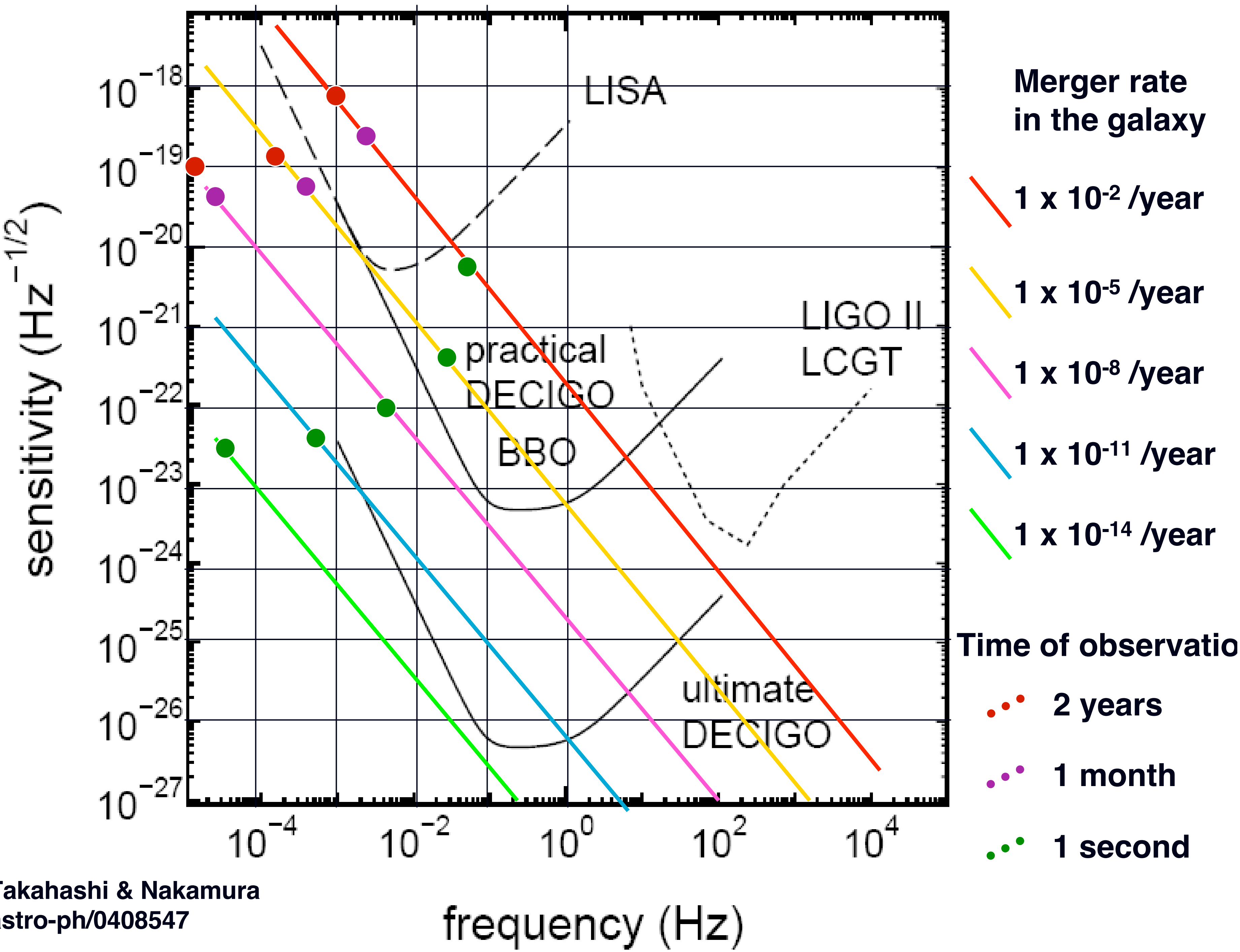

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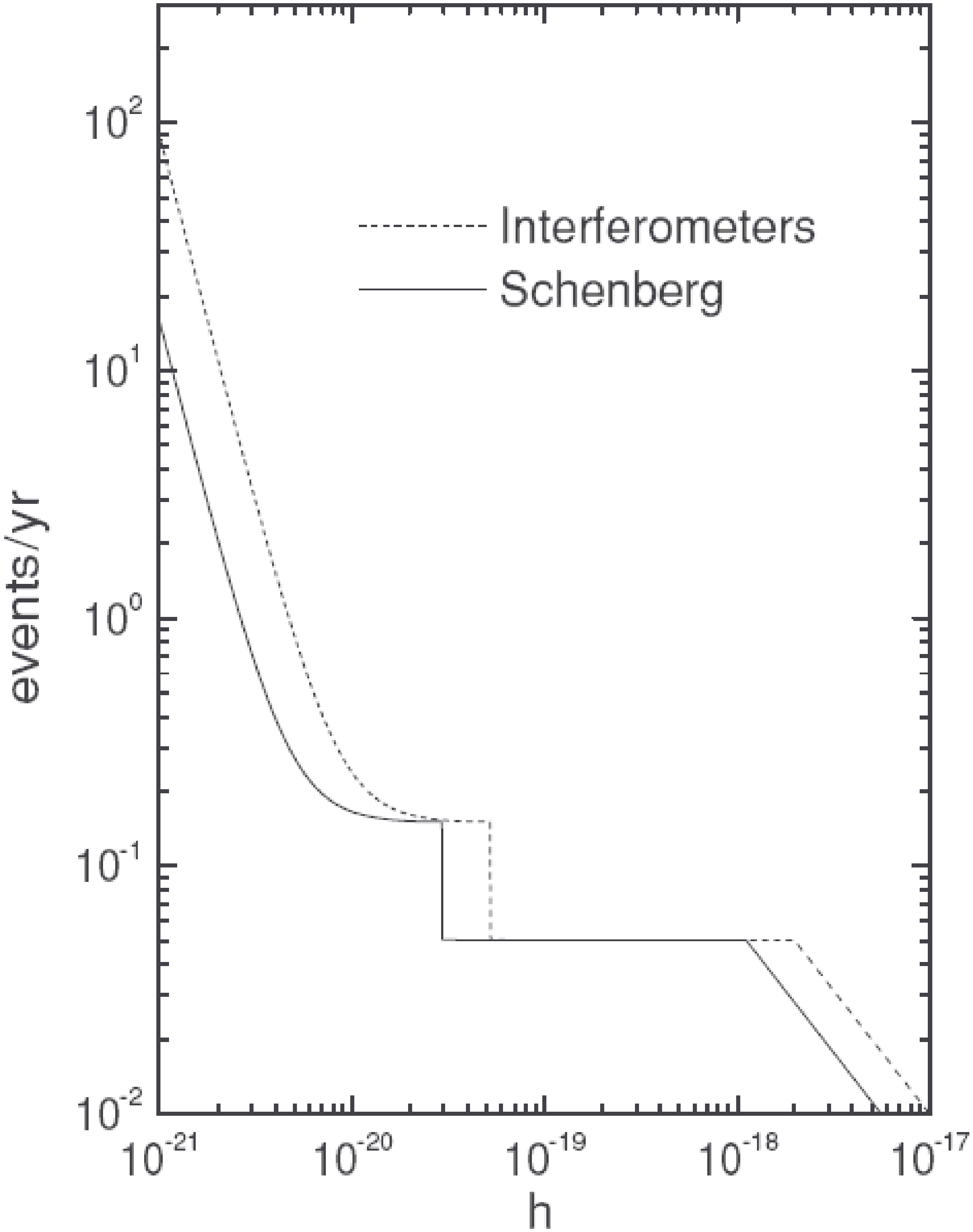
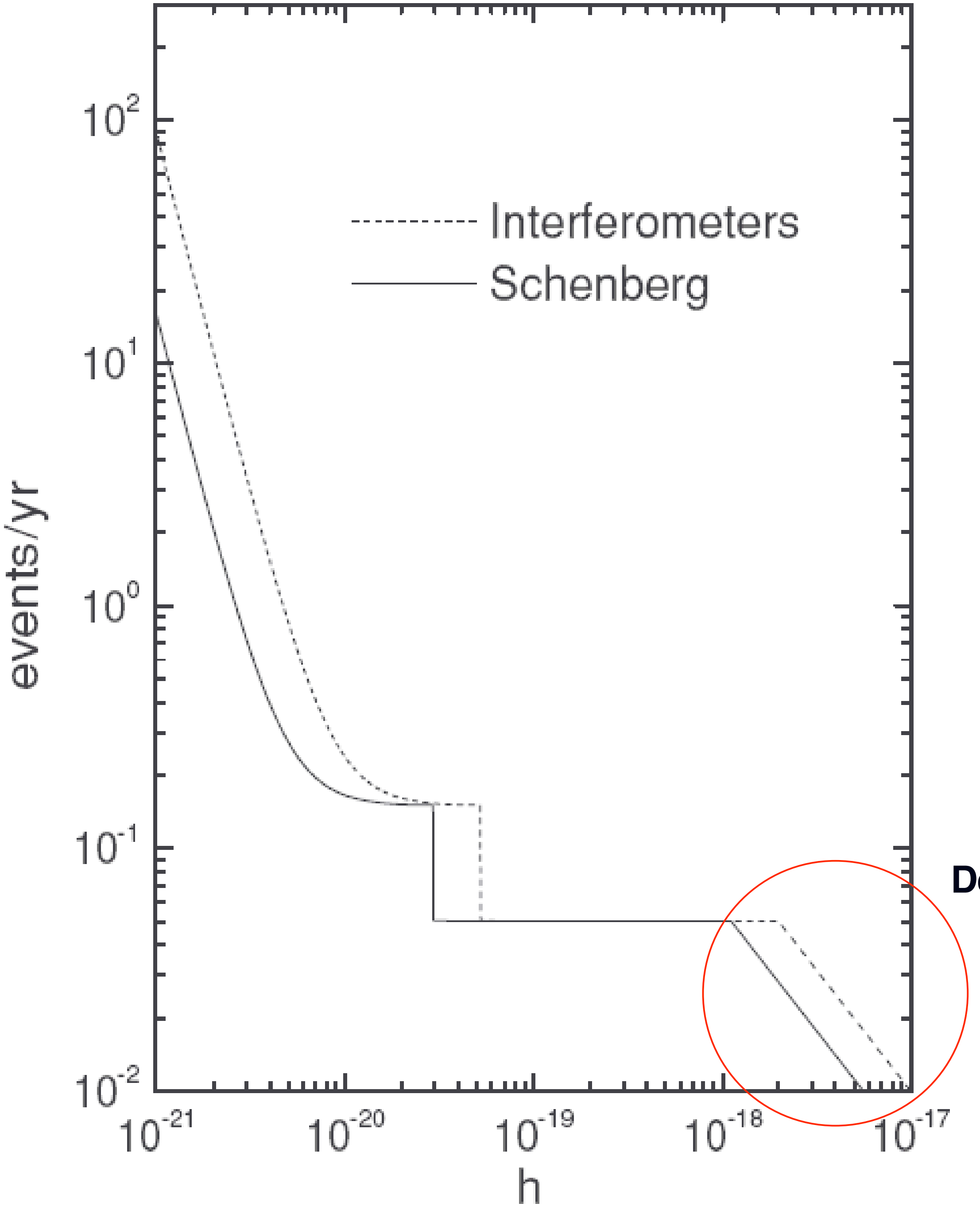
Very large ground base interferometers such as LIGO and VIRGO can soon give information that would put stringent constraints on these rates.



De Araujo et al, CQG (2004



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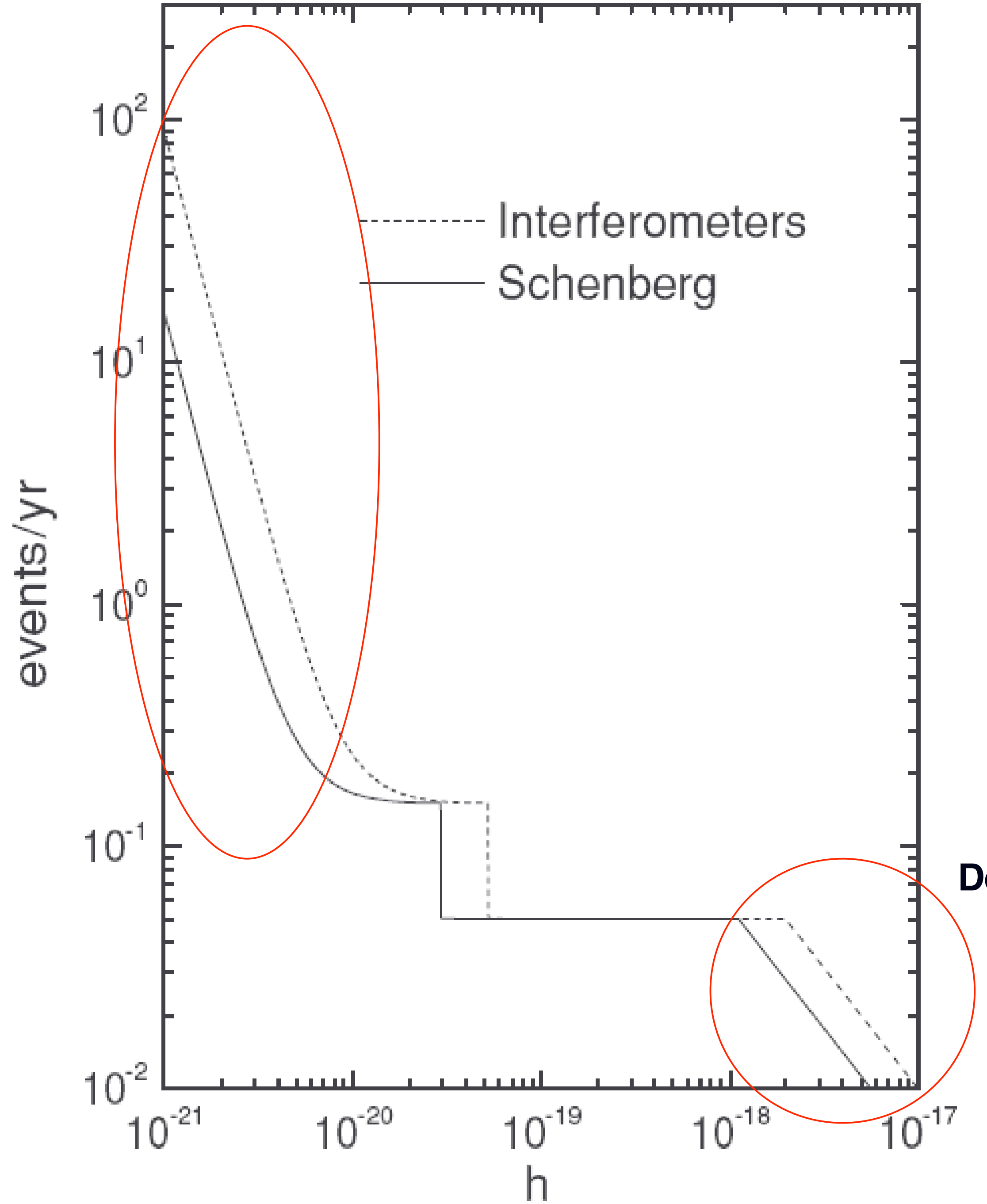

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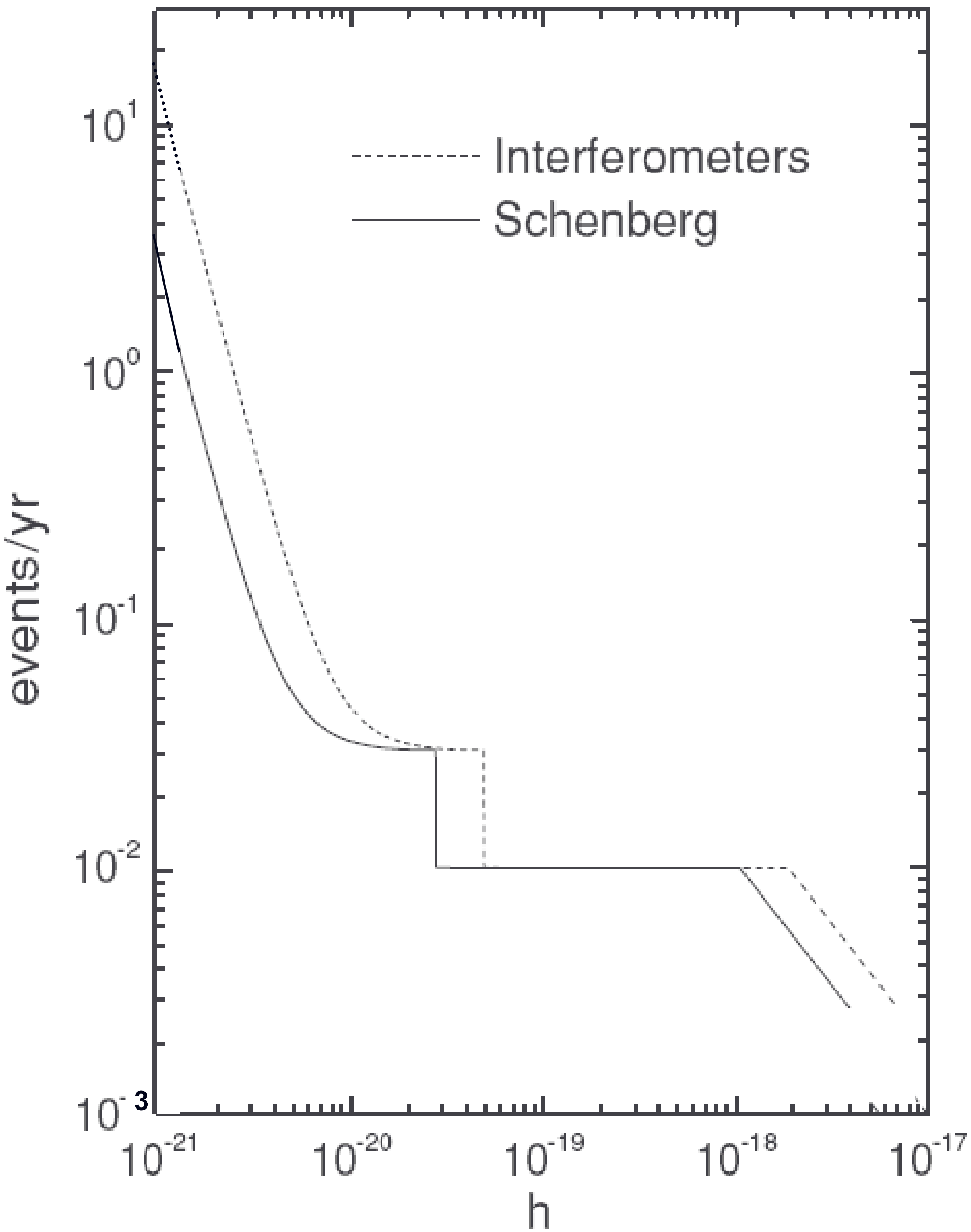

Abott et al. 2005 (based on the LIGO second science run) estimated a rate $R_m = 1.2 \times 10^{-2}\ yr^{-1}$ in the Milky Way Galaxy, assuming all MACHOs are PBHs

They also placed an observational upper limit on the rate of PBHs coalescence of 63 per year per Milky Way halo with a 90% confidence.

Conclusions

- If PBH binaries exist they will probably be seen by some of these three interferometers.
- Even for the highest estimated rate of PBH mergers in our Milky Way halo (~ 1.2 x 10^{-2} yr^{-1} MWH^{-1}), in which all MACHOs would be PBHs, we don't expect that PBH binaries will produce a confusion noise too much above the low end of the LISA sensitivity band. Furthermore, very large ground base interferometers such as LIGO and VIRGO can soon put constraints on this rate.
- DECIGO and BBO are free from facing this PBH confusion noise.

Abstract

According to the standard model primordial black holes (PBHs) could have been generated during the first few moments after the big bang as consequence of density fluctuations of matter. Although most regions of high density would be quickly dispersed by the expansion of the universe, primordial black holes would be stable, persisting to the present. If this really happened the Laser Interferometer Space Antenna (LISA), the DECihertz Interferometer Gravitational wave Observatory (DECIGO), and the Big Bang Observer (BBO) will probably detect the gravitational wave background produced by those PBHs. Here we calculated this background as a function of the PBH population in the neighborhood of Earth. Depending of what population is assumed the gravitational wave background produced may give trouble for these space interferometers in their task to detect other signals. Very large ground base interferometers such as LIGO and VIRGO can soon give information that would put stringent constraints on this population.